

IN THE CLAIMS:

The text of all pending claims, (including withdrawn claims) is set forth below. Cancelled and not entered claims are indicated with claim number and status only. The claims as listed below show added text with underlining and deleted text with ~~striketrough~~. The status of each claim is indicated with one of (original), (currently amended), (cancelled), (withdrawn), (new), (previously presented), or (not entered).

1. (original) A distortion correction device, comprising:
an outline extraction device extracting regular graphics attached to a piece of rectangular paper from an input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and
a distortion correction device correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

2. (currently amended) A distortion correction device, comprising:
an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the outline as a clue; and
a distortion correction device correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image; and
wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

3. (original) A distortion correction device, comprising:
an outline extraction device extracting horizontal and vertical lines written in a piece of rectangular paper from an input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical lines written in the paper as a clue; and

a distortion correction device correcting the distortion based on the three-dimensional curved- surface model and outputting a corrected image as an output image.

4. (original) A distortion correction device, comprising:

an outline extraction device extracting horizontal and vertical character strings written in a piece of rectangular paper from the input image obtained by photographing the paper;

a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical character strings written in the paper as a clue; and

a distortion correction device correcting the distortion based on the three-dimensional curved- surface model and outputting a corrected image as an output image.

5. (currently amended) A distortion correction device, comprising:

an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper; and

a distortion correction device correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image, and

wherein said outline extraction device evaluates outline likeliness indicating a ratio between both series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

6. (currently amended) A distortion correction device, comprising:

a curved-surface estimation device obtaining outline information about a piece of rectangular paper and estimating a three-dimensional curved-surface model of the paper using outline distortion obtained from the outline information as a clue; and

a distortion correction device correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image, and

wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

7. (currently amended) A distortion correction device, comprising:
an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the outlines; and
a distortion correction device correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image, and
wherein said outline extraction device evaluates outline likeliness indicating a ratio between both series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

8. (original) The distortion correction device according to claim 7, wherein the input and output images are one of a white-and-black binary image, a gradation image and a color image.

9. (currently amended) A distortion correction device, comprising:
an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the outlines; and
a distortion correction device correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image. and~~The distortion correction device according to claim 7,~~
wherein the input and output images are one of a white-and-black binary image, a gradation image and a color image, and
wherein said outline extraction device evaluates outline likeliness indicating a ratio between both series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

10. (currently amended) A distortion correction device, comprising:
an outline extraction device extracting an outline of a piece of rectangular paper from an
input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model
of the paper using distortion of the outlines; and
a distortion correction device correcting distortion using distortion of the outline as a clue
and outputting a corrected image as an output image, and~~The distortion correction device~~
~~according to claim 7,~~

wherein said outline extraction device evaluates outline likeliness indicating a ratio between both series of pixel strings with color of an external area of the paper and series of pixel strings with color of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

11. (original) The distortion correction device according to claim 10, wherein said outline extraction device uses a value obtained by performing a product sum of a pixel value arbitrarily extracted from the neighborhood of the outline pixel candidate horizontally or vertically including the outline pixel candidate and appropriately set fixed-value vector, as the outline likeliness.

12. (original) The distortion correction device according to claim 11, wherein said outline extraction device uses a value obtained by performing a product sum of both a horizontally symmetrical mask $k, k, k, \dots, k, 0, -k, \dots, -k, -k, -k$ and a vertically symmetrical mask $k, k, k, \dots, k, 0, -k, \dots, -k, -k, -k$ arrayed horizontally and vertically, respectively, including the outline pixel candidate using k as a positive or negative constant with value 0 at a center, as the outline likeliness.

13. (original) The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a sunken center-folded three-dimensional curved-surface model obtained by modeling sunken center-folded distortion as the three-dimensional curved-surface model.

14. (original) The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a raised center-folded three-dimensional curved-surface

model obtained by modeling raised center-folded distortion as the three-dimensional curved-surface model.

15. (currently amended) A distortion correction device, comprising:
an outline extraction device extracting an outline of a piece of rectangular paper from an
input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model
of the paper using distortion of the outlines; and
a distortion correction device correcting distortion using distortion of the outline as a clue
and outputting a corrected image as an output image. and~~The distortion correction device~~
~~according to claim 14,~~
wherein said curved-surface estimation device uses a raised center-folded three-
dimensional curved-surface model obtained by modeling raised center-folded distortion as the
three-dimensional curved-surface model.~~and~~

wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

16. (original) The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a raised circumference distortion three-dimensional curved-surface model obtained by modeling raised circumference distortion as the three-dimensional curved-surface model.

17. (original) The distortion correction device according to claim 7, wherein said curved-surface estimation device uses a curved-surface model obtained by applying linear Coons interpolation to a three- dimension outline model obtained by modeling a three-dimensional outline of the paper as the three-dimensional curved-surface model.

18. (original) The distortion correction device according to claim 17, wherein said curved-surface estimation device uses points on a three-dimensional outline as three-dimensional discrete sample points of the three-dimensional outline model and a value corresponding to height of each of the three-dimensional sample points as a model parameter.

19. (original) The distortion correction device according to claim 17, wherein said curved-surface estimation device uses a curved model with a parameter as the three-dimensional outline model.

20. (currently amended) A distortion correction device, comprising:
an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the outlines; and
a distortion correction device correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image wherein said curved-surface estimation device uses a curved model with a parameter as the three-dimensional outline model and
wherein said curved-surface estimation device uses a curved-surface model obtained by applying linear Coons interpolation to a three- dimension outline model obtained by modeling a three-dimensional outline of the paper as the three-dimensional curved-surface model, and~~The distortion correction device according to claim 19,~~
wherein said curved-surface estimation device uses a curved model with a parameter as the three-dimensional outline model, and
wherein said curved-surface estimation device estimates a three-dimensional curved-surface model by expressing a restriction that all curves with the same X-coordinate or Y-coordinate have the same length with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

21. (currently amended) A distortion correction device, comprising:
an outline extraction device extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;
a curved-surface estimation device estimating a three-dimensional curved-surface model of the paper using distortion of the outlines; and
a distortion correction device correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image, and
wherein said curved-surface estimation device uses a curved-surface model obtained by applying linear Coons interpolation to a three- dimension outline model obtained by modeling a

three-dimensional outline of the paper as the three-dimensional curved-surface model~~The distortion correction device according to claim 17, and~~

wherein said curved-surface estimation device uses values corresponding to height of two end points of a three-dimensional outline as model parameters of the three-dimensional outline model and restricts a location on a condition that points on a three-dimensional outline are on a vertical plane, including a three-dimensional line segment connecting the two end points.

22. (original) The distortion correction device according to claim 17, wherein said curved-surface estimation device uses a three-dimensional line segment as the three-dimensional outline model.

23. (original) The distortion correction device according to claim 7, wherein said curved-surface estimation device estimates a three-dimensional curved surface by estimating a three-dimensional outline by perspective conversion using the extracted outline as a clue.

24. (original) The distortion correction device according to claim 7, wherein said distortion correction device calculates a location in the input image, corresponding to each pixel of an image after correction using a curved coordinate system with the outline as a coordinate axis and obtains an image after correction with length of top/lower outlines and length of left/right outlines as width and height, respectively, by setting a value of a corresponding pixel in the input image as a target pixel value of the image after correction.

25. (original) A distortion correction method, comprising:
extracting regular graphics attached to a piece of rectangular paper from an input image obtained by photographing the paper;
estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and
correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

26. (currently amended) A distortion correction method, comprising:
extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;

estimating a three-dimensional curved-surface model of the paper using distortion of the outline as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image; and

wherein said curved-surface estimating estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

27. (original) A distortion correction method, comprising:

extracting horizontal and vertical lines written in a piece of rectangular paper from an input image obtained by photographing the paper;

estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical lines written in the paper as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

28. (original) A distortion correction method, comprising:

extracting horizontal and vertical character strings written in a piece of rectangular paper from the input image obtained by photographing the paper;

estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical character strings written in the paper as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

29. (currently amended) A distortion correction method, comprising:

extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper; and

correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image; and

wherein said outline extracting evaluates outline likeliness indicating a ratio between both series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline

pixel candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

30. (currently amended) A distortion correction method, comprising:
obtaining outline information about a piece of rectangular paper and estimating a three-dimensional curved-surface model of the paper using outline distortion obtained from the outline information as a clue; and
correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image, and
wherein said curved-surface estimating estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

31. (currently amended) A distortion correction method, comprising:
extracting an outline of a piece of rectangular paper from an input image obtained by photographing the paper;
estimating a three-dimensional curved-surface model of the paper using distortion of the outline; and
correcting distortion using distortion of the outline as a clue and outputting a corrected image as an output image, and
wherein said outline extraction evaluates outline likeliness indicating a ratio between both series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

32. (original) A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:
extracting regular graphics attached to the paper from the input image;
estimating a three-dimensional curved-surface model of the paper using distortion of the

regular graphics as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

33. (currently amended) A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting an outline of the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the outline as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image; and

wherein said curved-surface estimating estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

34. (original) A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting horizontal and vertical lines written in the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical lines written in the paper as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

35. (original) A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting horizontal and vertical character strings written in the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion at an intersection of the horizontal and vertical character strings written in the paper as a clue; and
correcting the distortion based on the three-dimensional curved-surface model and
outputting a corrected image as an output image.

36. (currently amended) A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting an outline of the paper from the input image; and
outputting a corrected image in which distortion of the outline is corrected, and
wherein said outline extracting evaluates outline likeliness indicating a ratio between both series of pixel strings with gradation of an external area of the paper and series of pixel strings with gradation of an internal area horizontally or vertically including a target pixel, out of outline pixel candidates obtained by performing edge extraction for the input image, and selects a likelier outline pixel candidate as an outline pixel.

37. (currently amended) A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in input outline information about the paper, the program enabling the computer to perform:

estimating a three-dimensional curved-surface model of the paper using outline distortion obtained from the outline information as a clue; and
correcting the distortion based on the three-dimensional curved-surface model and
outputting a corrected image as an output image, and
wherein said curved-surface estimating estimates a three-dimensional curved-surface model by expressing a restriction that a horizontal or vertical pair of length of three-dimensional outlines are the same with an energy function and solving an optimization problem of calculating a parameter of the three-dimensional curved-surface model, the energy of which becomes a minimum.

38. (currently amended) A computer-readable storage medium, on which is recorded a program for enabling a computer to correct outline distortion of a piece of rectangular paper, included in an ~~image~~ image obtained by photographing the paper, the program enabling

outline as a clue; and

correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

39. (original) A distortion correction device, comprising:

outline extraction means for extracting regular graphics attached to a piece of rectangular paper from an input image obtained by photographing the paper;

curved-surface estimation means for estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

distortion correction means for correcting the distortion based on the three-dimensional curved-surface model and outputting a corrected image as an output image.

40. (original) A propagation signal for propagating a program to a computer for correcting outline distortion of a piece of rectangular paper, included in an image obtained by photographing the paper, the program enabling the computer to perform:

extracting regular graphics attached to the paper from the input image;

estimating a three-dimensional curved-surface model of the paper using distortion of the regular graphics as a clue; and

correcting the distortion based on the three-dimension curved-surface model and

outputting a corrected image as an output image.